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(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

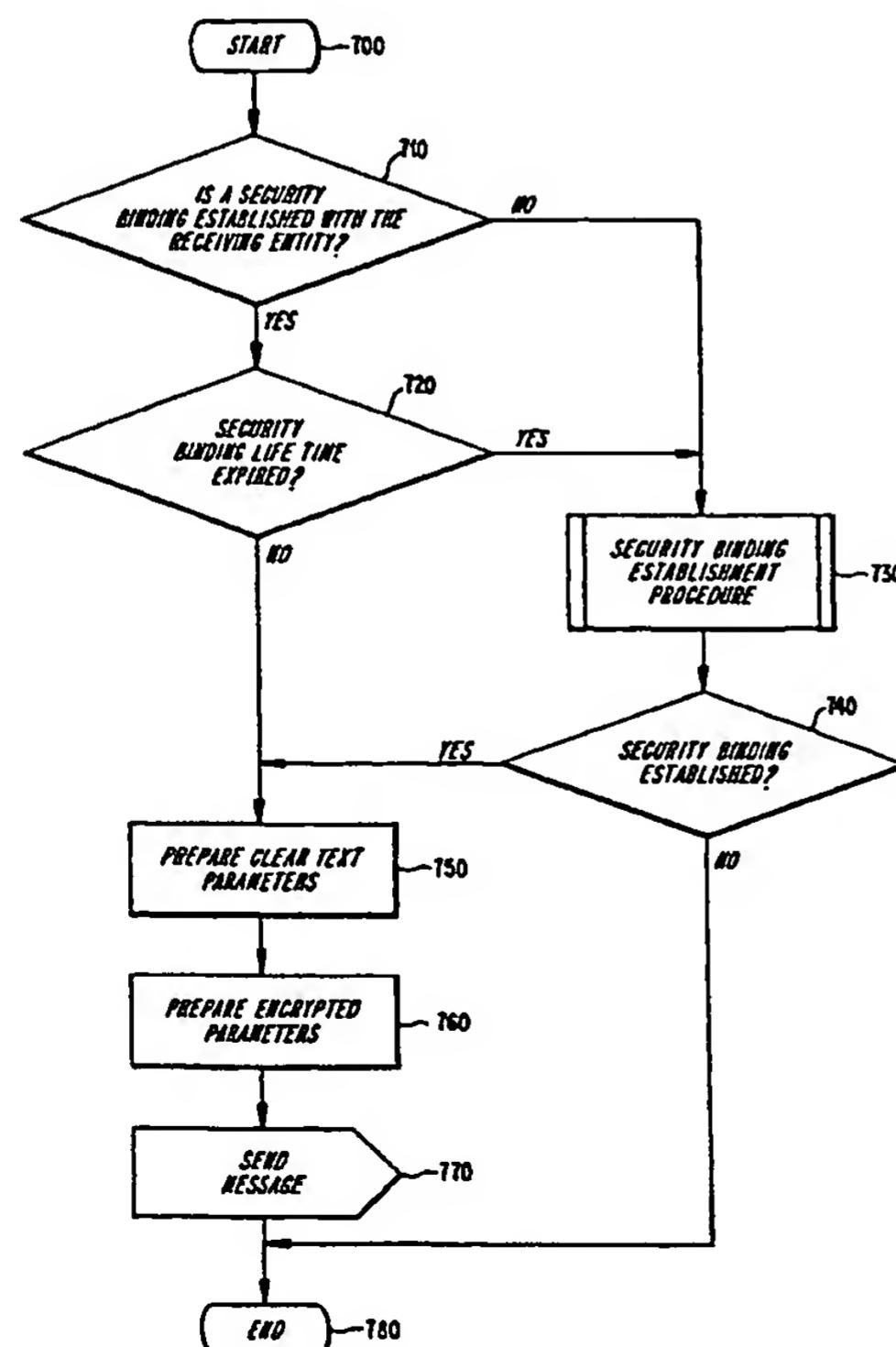
(72) Inventors: SANCHEZ HERRERO, Juan Antonio; Calle Desengano, 24 1 Centro, E-28004 Madrid (ES). CALATRAVA REQUENA, Odelin; Calle General Kirkpatrick, 6, E-28027 Madrid (ES).

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(54) Title: METHOD AND APPARATUS FOR SECURE COMMUNICATION



(57) Abstract: Secure communication is provided for entities in one or more networks. It is determined whether security measures needed for the communication exist between the entities. If such measures do not exist, the security measures are established, and the communication is initiated. The security measures include security bindings including information needed for the secure communication. Security measures are established between entities in one or more networks based on predetermined security requirements and on a determined needed security level. The security level needed may be determined based on whether the entities are in the same network or in different networks and/or on the information being transmitted. Security bindings are established between the entities depending on the information to be transmitted and/or the network to which the entities belong. The security bindings include information identifying the security binding, encryption information, authentication information, integrity information, a list of addressees or group of addressees included in the security bindings, and/or information regarding the lifetime of the security bindings. The encryption, authentication, and integrity may be specified at a parameter level.

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METHOD AND APPARATUS FOR SECURE COMMUNICATION

BACKGROUND

This invention relates generally to a method and apparatus for secure communication. More specifically, this invention relates to a method and apparatus for 5 secure communication between entities in the same or in different communication networks.

There are many types of public land mobile networks, e.g., a Global System for Mobile Communications (GSM), a Digital Cellular System for Mobile Communications (DCS 1800), a Personal Communication System (PCS), and a Universal Mobile 10 Telecommunication System (UMTS). These networks provide a wide range of services and facilities to mobile subscribers that are roaming around between individual cells of the mobile radio communication networks. An exemplary network architecture for mobile radio communication systems such as those is shown in FIG. 1.

A typical network includes at least one Home Location Register (HLR) 100 for 15 storing information about subscribers to the network, a Visitor Location Register (VLR) 110 for storing information about subscribers to other networks that may be roaming in the network, a Mobile Services Switching Center (MSC) 120 for performing switching functions for the mobile stations, a Gateway MSC (GMSC) 130 for routing incoming calls to the PLMN to the appropriate MSC, and an SMS Gateway MSC (SMSGMSC) 20 140 which is an interface between the mobile network and a network providing access to the short message service center for delivery of short messages to the mobile stations via a Switching Center (SC) 150. A Base Station Controller (BSC) 160 and a Base Transceiver Station (BTS) 170 are part of the base station system equipment for connecting the network to a mobile station 180. An Equipment Identity Register (EIR) 25 190 handles management of the equipment identities of the mobile stations.

As shown in FIG. 1, other entities may be connected to the network. For example, a Switching Network 210 may be connected to the network via the GMSC 130, a Packet Network 220 may be connected to the network via a General Packet Radio Service Support Node (GSN) 200, and another PLMN 230 may be connected to another GMSC 30 130. A Fraud Detection System (FDS) 240 may be connected to several types of entities

in the network, e.g., the HLR 100 and another MSC 120, from which it obtains information for specific subscribers. The information collected may include information regarding the charging data records generated, e.g., at the MSCs, the location information of the subscribers, which is generally generated at the HLR, and information regarding 5 the activity generated in real time (such as the number of call forwarding registrations performed in a period of time, the number of parallel calls made in that time, etc.). The FDS 240 discovers possible fraud risk situations. For example, the FDS 240 detects when a subscriber suddenly has a really high charging record that has previously never occurred. As another example, the FDS 240 detects when a subscriber generates several 10 parallel calls to certain countries, which might indicate call selling activities. As a third example, the FDS 240 detects when a subscriber is located in two different distant places within a very short interval of time, which may indicate cloning activities.

The entities of the PLMN communicate via a common signalling system. For example, in the GSM System, the Mobile Application Part (MAP) of the Signaling 15 System No. 7 specified by CCITT is used to communicate between entities in the PLMN. Details of this signalling system are given in Digital Cellular Telecommunications System (Phase 2+), Mobile Application Part (MAP) specification, TS GSM 09.02 v.5.6.00, which is incorporated herein by reference.

Based on roaming agreements between mobile network operators, the mobile 20 subscribers belonging to a specific PLMN 250, referred to as a Home PLMN (HPLMN), can make use of their services and facilities while roaming in another PLMN network 260, referred as a Visitor PLMN (VPLMN). FIG. 2 shows an exemplary configuration of a network architecture for a roaming scenario. Similar to FIG. 1, a FDS 240 is connected to entities such as the HLR 100 and the MSCs 120.

25 With the continuos growth of network elements, transmission media, etc., more refined fraud methods have been developed. Such methods involve attacks on the signalling system. Using GSM as an example, the security of the global SS7 network as a transport system for sensitive signalling messages is open to major compromise. Messages can be eavesdropped, altered, injected or deleted in an uncontrolled medium. 30 confidential information has recently been added in the GSM standards to the signalling

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protocols which will increase the confidentiality risk due to the lack of confidentiality in the signalling media. Such confidential information includes, e.g., location information based on geographical coordinates, charging information, etc. These risks will further be increased by the possible future use of open signalling protocols for signalling

5 transmission, e.g., Transmission Control Protocol/Internet Protocol (TCP/IP). While the current GSM specification provides for authentication of mobile subscriber identities, there is no authentication of network entities defined in GSM. Some restriction policies exist, but there is no mechanism for assuring that the identity information has not been manipulated.

10 There is a need for a method for transmitting certain confidential information through mobile communication networks protected from attacks performed by accessing the signalling network. User confidentiality can be attacked by accessing certain information included in signalling messages. This information relates mainly to the origin/destination of the calls and location of the subscriber. Other attacks to the network

15 operation may occur by impersonating a network node or network entity. The main threats faced from subscriber impersonation are the manipulation of answers to authentication procedures and the eavesdropping of authentication information. Such impersonation permits access to confidential information and may even result in a change to specific service behavior (e.g., Customized Applications for Mobile Network

20 Enhanced Logic (CAMEL) charge services, location services, Supplementary Services (SS) procedures, redundancy, etc.), which may result in fraud and/or affect the network behavior.

The service availability can be compromised at the user level, based on manipulation of subscription information or messages granting the service. The service

25 availability can also be compromised at the network level, by deletion of resource liberation related messages, e.g., deletion of a message indicating a subscriber's location, or by overloading the network through message injection.

There is thus a need for authenticating an originating node or network entity in order to initiate confidential communications between entities in one or more networks.

SUMMARY

It is therefore an object of the present invention to provide a technique for secure communication. It is yet another object of the present invention to provide a technique for authenticating network entities for confidential communications.

- 5 According to an exemplary embodiment of the present invention, these and other objects are met by a method and apparatus for secure communication between entities in one or more networks. A determination is made whether security measures needed for the communication exist between the entities. If such measures do not exist, the security measures are established, and the communication is initiated. The security measures
- 10 include security bindings including information needed for the secure communication. Security measures are established between entities in one or more networks based on predetermined security requirements and on a determined needed security level. The security level needed may be determined based on whether the entities are in the same network or in different networks and/or on the information being transmitted. Security
- 15 bindings are established between the entities depending on the information to be transmitted and/or the network to which the entities belong. The security bindings include information identifying the security binding, encryption information, authentication information, integrity information, a list of addresses or group of addressees included in the security bindings, and/or information regarding the lifetime of the security bindings.
- 20 The encryption, authentication, and integrity may be specified at a parameter level.

BRIEF DESCRIPTION OF THE DRAWINGS

- 25 The features, objects, and advantages of the invention will become apparent by reading this description in conjunction with the accompanying drawings, in which like reference numerals refer to like elements and in which:

FIG. 1 illustrates an exemplary network architecture for mobile radio communication systems;

FIG. 2 illustrates an exemplary network architecture for a roaming scenario;

FIG. 3 illustrates a key life cycle;

- 30 FIG. 4 illustrates a system for secure communication according to an exemplary

embodiment;

FIG. 5A illustrates a message sequence for the transmission of key management information;

5 FIG. 5B illustrates a detailed example of a process for establishing a security binding;

FIG. 6 illustrates a message sequence for the transmission of encrypted information;

FIG. 7 illustrates an entity procedure for transmitting encrypted information;

10 FIG. 8 illustrates a message sequence for the transmission of authentication information; and

FIG. 9 illustrates a message sequence for the transmission of integrity information.

DETAILED DESCRIPTION

A general premise of any security analysis is that the weakest point in the security 15 chain may compromise the complete security system. In a signalling system, the chain comprises a number of signalling protocols, such as Integrated Services Digital Network (ISDN) User Part (ISUP), Data Transfer Application Part (DTAP), Base Station System Application Part (BSSAP), GPRS Transfer Protocol (GTP), CAMEL Application Part (CAP), Intelligent Network Application Protocol (INAP), etc. For illustrative purposes, 20 the following discussion is directed towards the Translation Capability Application Part (TCAP) and Mobile Application Part (MAP) protocols. However, it will be appreciated that the invention is not limited to applications using these protocols, but may be applicable to other protocols.

According to an exemplary embodiment, security may be managed using one or 25 more of four mechanisms: data encryption, authentication, integrity, and key management. Data encryption is used to assure confidentiality of transmitted information, authentication is used to assure that the messages received from a certain entity have not been injected or replayed by intruders, integrity is used to assure that the information has not been manipulated, and key management is used to manage the 30 encryption, authentication, and integrity mechanisms. The key management mechanism

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allows flexible handling of keys upon which the encryption and authentication mechanisms are based.

There are various considerations to be taken into account when considering how to apply these mechanisms. For example, backward compatibility when communicating with entities not supporting the signalling security mechanism should be maintained. Also, forward compatibility should be made possible, allowing adaptation to further needs and emerging technologies (e.g., new encryption algorithms, future transmission of sensitive information, etc.). The impact of the security mechanisms on network performance should be minimized. The number of entities in the network with high security requirements should also be minimized. Handling of roaming scenarios should be made simple. High granularity in the application of the security mechanisms at the network, entity, procedure and subscriber levels should be provided, such that different security levels can coexist.

According to exemplary embodiments, all of the mechanisms do not have to be applied. For example, if the information contained in a message is considered important by itself, this implies that in some cases it may be desirable only to apply data encryption (to avoid eavesdropping) or only to apply data integrity (to avoid manipulation), independently of the other requirements. Thus, according to exemplary embodiments, the mechanisms are as independent as possible in order to allow the independent application of the mechanisms and to simplify the adaptation of the mechanisms to emerging technologies.

According to an exemplary embodiment, a key management system is proposed, and the encryption and authentication mechanisms take advantage of it in order to simplify the complete procedure. Since key management is commonly used by the other mechanisms, the key management mechanism will be described first.

KEY MANAGEMENT

Key management is the administration and use of the services of generation, registration, certification, de-registration, distribution, installation, storage, archiving, revocation, derivation and destruction of keying material. The objective of key

management is the secure administration and use of these key management services.

The protection of keys is extremely important. The appropriate protection of keys depends on the threats they face. Problems that arise in key distribution are the number of entities involved in the communication and the nature of them. Since mobile
5 networks such as the GSM/UMTS network allow roaming, there is communication between several entities out of the operator security domain. On the other hand, each operator may need to have complete control over the security in the entities.

Security bindings between entities indicate the allowed communication between entities and the characteristics of the encryption, authentication, and integrity mechanisms
10 used and specific characteristics of the corresponding binding. According to an exemplary embodiment, the security bindings include information such as a binding identity, which uniquely identifies the security binding, encryption, which specifies the parameters to be encrypted, the algorithms applicable (e.g., BEANO) and the session key used, authentication, which refers to messaging requiring authentication, the
15 authentication system applicable and the key used, integrity, which refers to messages requiring integrity and the integrity system applicable, lifetime, which is the time during which the security binding is considered applicable, and destinations, which includes a list of addresses or group of addresses (e.g., MSISDN series) included in the security binding.

20 Using a common Signalling System between entities will originate a huge amount of possible messages using a certain key, which allow attacks based on massive information. This can be avoided by the use of very strong authentication mechanisms which usually are based on large keys and block sizes, implying an undesirable impact in the system performance.

25 The problem of attacks based on massive information can be avoided by frequent key changes. Thus, according to an exemplary embodiment, session keys, which only remain valid for a particular communication session, may be used.

30 A session key is only made valid during a prescribed period. Thus, the keys are temporary and subject to modification after the prescribed period. A life cycle is therefore associated with each key. A typical life cycle of a key is illustrated in FIG. 3.

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The life cycle includes three principal states: pending active, active, and post active. When a key is generated, it enters the pending active state 300. In the pending active state 300, a key has been generated, but has not been activated for use. The key remains in the pending active state until it is either destroyed or activated for 5 cryptographic operations. Upon activation, the key enters the active state 310. In the active state 310, the key is used to process information cryptographically. The key remains in the active state until it is deactivated, which limits a key's use, e.g., because the key has expired or has been revoked. Upon deactivation, the key has limited use and enters the post active state 320. In the post active state 320, the key is only used for 10 decipherment or verification. The key remains in the post active state until it is either destroyed or is reactivated. Reactivation allows a post-active key to be used again for cryptographic operations, at which point it returns to the active state 310.

The number of entities exponentially increases the need for security bindings between cooperating entities. If the security bindings between the entities are 15 independent for each communicating pair, this will negatively impact processing and performance. But, if the same key is shared in several security bindings, the probability of breaking it increases, which may result in a breakdown of the entire security system.

To address this problem, the number of entities that shall be authenticated by parties outside the operator security domain should be minimized. Therefore, according 20 to exemplary embodiment, only a few entities in each network are authenticated by Trusted Third Party (TTP) systems.

According to an exemplary embodiment, the functionality of key handling in the operator domain may be based on an existing Authentication Center (AuC). The AuC contains information for authenticating subscribers at the attachment phase to the network 25 of the mobile terminals, e.g., when the subscribers switch on the mobile terminals, and the mobile attach to the network. This is advantageous because the AuC already has strong security requirements that may be used for this application. In addition, in the GSM system, AuC's handle MAP protocol that can be easily used for communicating entities such as a VLR, MSC, and HLR, etc., to handle key distribution.

30 An exemplary basic key management architecture showing the security bindings

between network entities is shown in FIG. 4. There are three different security levels: Inter PLMN level, Intra PLMN level, and Session level.

The Inter PLMN level is used for establishing security bindings between entities belonging to different PLMNs. For example, as shown in FIG. 4, security bindings are 5 established between the TTP and the AuC_A of Network A, and between the TTP and the AuC_B of Network B. These security bindings are established based on predetermined security requirements, e.g., based on either bilateral agreements between PLMN operators or by trusting in an external co-operation or entity acting as a TTP, i.e., an entity used to authenticate other entities. These security bindings have strong security 10 requirements and the specific mechanism used should be enough flexible to allow state of the art techniques. The TTP may be integrated with other systems outside the network. Nevertheless, a default mechanism should be supported to provide this security bindings in a multivendor environment.

According to an exemplary embodiment, the Intra PLMN level is used for 15 establishing security bindings between entities belonging to the same PLMN. At the Intra PLMN level, one or more AuC entities (with security bindings established) act as a TTP for the entities in the PLMN. For example, as shown in FIG. 4, a security binding exists between AuC_A and AuC_B. These security bindings may be established at the operator premises, to allow the establishment of different standard and customized security 20 schemes. Nevertheless, some standard mechanisms should be supported to provide the security bindings in a multivendor environment.

The Session level is used for establishing security bindings between communicating entities. The session established will be handled through the AuC (or AuCs) assigned to the entities. Each entity trusts in its corresponding AuC. For example, 25 as shown in FIG. 4, Network Entities in Network A, NE_A, are connected to the AuC_A via security bindings. Similarly, Network Entities in Network B, NE_B, are connected to AuC_B by security bindings. Also, the Network Entities NE_A and NE_B are connected to each other via security bindings. Although one AuC is shown for each network in FIG. 4 for simplicity of illustration, it will be appreciated that more than one AuC may be 30 employed in each network and that more than one AuC may be assigned to each entity in

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the network.

At the Session level, there are two types of communication possible, depending on the type of communication (Inter PLMN or Intra PLMN). If the communication is Inter PLMN, i.e., between entities in different networks, the selected identification mechanism 5 should allow the establishment of different standard security schemas. If the communication is Intra PLMN, i.e., between entities within the same network, the selected mechanism should allow the establishment of different standard and customized security schemas. Nevertheless, some standard mechanisms should be supported to provide the security bindings in a multivendor environment.

10 So, the selected mechanism should allow the establishment of different standard and customized security schemas. According to an exemplary embodiment, the security bindings may be based in MAP protocol.

As a consequence of installation, each entity will have enough information to contact the AuC responsible for its signal security. Security bindings to different levels 15 will be established, first to the Intra HPLMN level and then to the Session level.

The sequence shown in FIG. 5A illustrates an exemplary message flow for transmission of key handling information. First, the Sending Entity checks whether the security binding has been established with the Receiving Entity or whether the security binding has expired. Next, the Sending Entity sends a Security Binding Request message 20 to the Sending Entity AuC. The Sending Entity AuC maintains information about the desired security bindings for the Sending Entity, indicating for each attribute whether the attribute is requested or negotiable. The Sending Entity AuC sends a Security Binding Request message to the Receiving Entity AuC. The Receiving Entity AuC sends a message to the Receiving Entity, and the Receiving Entity determines which attributes it 25 can handle and responds to the Receiving Entity AuC with the accepted security binding attributes. The Receiving Entity AuC then responds to the Sending Entity AuC with the accepted attributes. The Sending entity AuC sends a Security Binding Acceptance message to the Sending Entity, indicating acceptance of the attributes specified by the Receiving Entity. If the accepted attributes are considered sufficient for the 30 communication, the Sending Entity responds to the Sending Entity AuC with a Security

Binding Acceptance acknowledgment message, and this message is forwarded to the Receiving Entity via the Receiving Entity AuC.

As an alternative, the Receiving Entity AuC can determine which attributes are acceptable and send a Security Binding Notification Message to the Sending Entity AuC 5 and the Receiving Entity indicating the acceptable attributes. This alternative may be acceptable, e.g., when the Receiving Entity AuC has information specifying which attributes the Receiving Entity can handle.

According to an exemplary embodiment, the key handling messages are sent encrypted and authenticated, with integrity information included.

10 FIG. 5B illustrates a detailed example of a process for establishing a security binding. In this figure, a method for establishing a security binding between an HLR and a VLR is shown as an example. The method begins with the HLR initiating a request to establish a security binding to the VLR. The request includes proposed algorithms, e.g., Alg 1 and Alg 2, and the level of security for the parameters, e.g., class 2 for 15 authentication information and charging data, class 1 for location, and class 0 for the remainder of the data. The HLR address is also included. Since the security binding has not been established yet, there is no security binding identity included. The request is received by the AuC for the HLR, AuC₁, and transmitted to the AuC for the VLR, AuC₂. AuC₂ transmits the request to the VLR, includes a key request and assigns a security 20 binding identity. The VLR determines which of the proposed algorithms and security classes it can handle and replies with an appropriate message, e.g., an acceptance message that indicates acceptance of Alg 2 and acceptance of the security classes. The acceptance message also provides the VLR address. The acceptance message is forwarded from AuC₂ to AuC₁, and AuC₁ transmits the acceptance message to the HLR. The HLR replies with 25 an acceptance acknowledgment, which is transmitted to AuC₁. AuC₁ forwards this message to AuC₂, and AuC₂ transmits this message to the VLR. After the acceptance acknowledgment is received by the VLR, the security binding establishment is completed.

DATA ENCRYPTION

30 There are many types of confidential information that may be transmitted between

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network entities, e.g., location information, charging information and triplets, i.e., information elements used to authenticate subscribers, including random, figured response, and ciphering key. For example, this information can be identified in MAP and Capability Application Part (CAP) protocols in the following messages:

5 **Location Information**

	Parameter	Message	Protocols
	RESULT	ProvideSubscriberInfo	MAP
	Parameter:LocationInformation	(HLR->MSC/VLR)	V1, V2, REL96, REL97
10	RESULT	SendRoutingInfo	MAP
	Parameter:LocationInformation	(HLR->GMSC)	REL96, REL97
	RESULT	Anytime interrogation	MAP
	Parameter:LocationInformation	(gsmSCF->HLR)	REL96
	ARGUMENT	Initial DP	CAP
15	Parameter:LocationNumber	(gsmSSF->gsmSCF)	

Table I

Charging Information

	Parameter	Message	Protocols
	Result parameter	FurnishChargingInfo	CAP
20	PartyToChange	(SRR->SSP)	REL97
	RESULT	FurnishChargingInfo	CAP
	Parameter FreeFormatData	(SCP->SSP)	REL97

Table II

Triplets

Parameter	Message	Protocols
RESULT	SendAuthenticationInfo	MAP
5 Parameter: Authentication set	(MSC/VLR -> HLR, VLRa -> VLRb)	V1, V2, REL96, REL97

Table III

A consequence of the examples above is that the parameters are not present in all the messages and that usually they are only a small part of the complete message 10 requesting confidentiality. Another consideration is that the information used for addressing purposes (e.g., at the Signalling Connection Control Part (SCCP)) can be accessed at lower levels than MAP or CAP protocols (e.g., International Mobile 15 Subscriber Identity (IMSI), Mobile Services Integrated Services Digital Network (MSISDN), VLR number, etc.). As a consequence, the security chain for this information is vulnerable, and it does not make sense to protect it at an Application Part level.

Therefore, according to an exemplary embodiment, confidential information is encrypted at the parameter level, removing these parameters from the ClearText part and including them in a new Encrypted part of the MAP operation, e.g.:

Param_1, Param_2, Param_3, Param_4

20 If *Param_2* and *Param_4* are confidential

ClearText(Param_1, Param_3), Encrypted(Param_2, Param_4)

The sequence shown in FIG. 6 illustrates an exemplary message flow corresponding to the transmission of encrypted parameters. As shown in FIG. 6, the 25 Sending Entity checks whether the security binding has been established with the Receiving Entity or whether the security binding has expired. If the security binding has not been established, or the lifetime has expired, the security binding is established, e.g., using the process shown in FIG 5A. Next, a message with the information is sent. The confidential parameters (identified by the security binding) are encrypted in the Sending

Entity. Then, the message with encrypted information is answered. The confidential parameters (identified by the security binding) are encrypted in the Receiving Entity.

The encrypted information can be included in a new standard parameter (e.g., *encrypted information*), the content of which is completely encrypted (except tag and length). The encrypted information may comprise a set of standard and proprietary parameters including information considered sensitive which should not be transmitted following the normal coding. The content of this encrypted information parameter can be defined either on a message basis or as a common data type that can be used in all applicable operations including, as an option, all possible parameters that could contain sensitive information. This parameter can contain authentication information, integrity information, padding octets and all other information requested by the selected security mechanism.

The selection of encrypted information may be performed in the sending entity according to the established security binding. FIG. 7 shows an exemplary entity procedure for selecting encrypted information. The process begins at step 700. At step 710, a determination is made whether a security binding has been established with the Receiving Entity. If so, a determination is made whether the security binding lifetime has expired at step 720. If, at step 710, it is determined that the security binding has not been established with the Receiving Entity or at step 720 it is determined that the security binding lifetime has expired, a security binding establishment procedure such as that shown in FIG. 5A is performed at step 730. Then, a determination is made whether the security binding is established at step 740. If it is determined that the security binding is not established at step 740, the process ends at step 780.

From a determination at step 790 that the security binding lifetime has not expired or a determination at step 740 that the security binding has been established, the method proceeds to step 750 at which clear text parameters are prepared. At step 760, encrypted parameters are prepared. At step 770, the message is sent, and at step 780, the process ends.

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ENTITY AUTHENTICATION

Some operations may cause undesired behavior in the network when injected by impersonating trusted entities. In principle, all operations may be used for illegal purposes. Some examples are given in Table IV:

	Message	Effect	Protocols
5	Update location (VLR->HLR)	Allow originating services to unregistered subscribers	MAP
10	ProvideSubscriberInfo (HLR->MSC/VLR)	Allow unallowed terminating calls	MAP
15	InsertSubscriberData (HLR->VLR)	Allow services not provided to the subscriber Allow arming CAMEL TAPS	MAP
	InterrogateSS (HLR->VLR)	Request subscriber information	MAP
	Anytime interrogation (gsmSCF->HLR)	Request subscriber information	MAP
	Initial DP (gsmSSF->gsmSCF)	Its interception allows overcome possible controls	CAP

Table IV

As can be seen from the examples above, different messages may affect network behavior differently. Thus, as a consequence, not all entities have the same authentication requirements. Also, depending on the operation, the sending or receiving entity may request authentication (e.g., in a Location Updating (LU) operation, the receiving may request authentication, while in an Insert Subscriber Data (ISD) operation, the sending entity may request authentication, etc.). Another consideration, as noted above with regard to encryption, is that the information used for addressing purposes (e.g., at the SCCP) can be accessed at lower levels than MAP or CAP protocols (e.g., IMSI, MSISDN, VLR number, etc.) and changed. As a consequence, it does not make sense to protect this information at an Application Part level.

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According to an exemplary embodiment, entity authentication is applied on a per entity basis, only to selected operations. A new Authenticator parameter may be included in the new Encrypted part of the MAP operations, e.g.:

Param_1, Param_2

5 If the sending entity is to be authenticated:

ClearText(Param_1, Param_2), Encrypted(Authenticator)

There are various types of authentication used between entities.

For example, in type 1 authentication, the sending entity uses the key for the domain so the confidentiality and authenticity will be based on the security of the keys.

10 This allows implicit authentication. Explicit authentication can be done if digital signatures are included in the messages as new parameters.

In type 2 authentication, explicit authentication is possible when key exchange is initiated. When the key agreement is established, the certificate can be provided from the TTP to the sending entity. This allows the sending entity to send the certificate to the 15 receiving entity. Assuming the key is secure, during the active period of the key, only the sending entity will be able to send encrypted information to receiving entity using that session key. A certificate in this case may be $Kn2[Ksn1n2, ID(N1), T, LKsn1n2]$.

Assuming the key is secure during the active period of the key, implicit authentication occurs.

20 When data is transferred, explicit authentication is possible as well, for example using digital signatures. For example, the message will generate a message digest using a hash function and then apply a digital algorithm to the digest.

Type 3 authentication is the same as type 2 authentication, and a certificate in this case may be $eKsn2[eKpn2[Ksn1n2, ID(N1), T, Lks]/TVP]$. Explicit signature is 25 possible, as well.

The sequence shown in FIG. 8 illustrates the message flow for the transmission of authentication information. First, the Sending Entity checks whether the security binding has been established with the receiving entity or if it has expired. If the security binding has not been established, or the lifetime has expired, the security binding is established, 30 e.g., using the process shown in FIG. 5A. Next, a message with Authentication

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information is sent. Then, the Authentication parameter (identified by the security binding) is encrypted in the Sending Entity. A Message with Authentication information is answered. The Authentication parameter (identified by the security binding) is encrypted in the Receiving Entity.

5 The Authentication Information can be included in a new standard parameter (e.g., entityAuthenticationInformation) into the encrypted Information parameter described above. The Authentication Information may be included in a container including the digital signature according to the security binding established between the communicating entities.

10 Although not shown, an entity procedure similar to that shown in FIG. 7 may be performed for transmission of authentication information.

DATA INTEGRITY

According to an exemplary embodiment, the integrity of the information is assured by including Integrity Information in the Encrypted part of the MAP operation calculated based in the message content and other potential information (e.g. TVP, time stamp, sequence number, etc.), e.g.:

Param_1, Param_2

If the message integrity is to be assured:

20 *ClearText(Param_1, Param_2), Encrypted(Integrity)*

The sequence shown in FIG. 9 illustrates the message flow corresponding to the transmission of Integrity Information. First, the Sending Entity checks whether the security binding has been established with the receiving entity or if it has expired. If the security binding has not been established or the lifetime has expired, the security binding is established, e.g., using the process shown in FIG. 5A. Next, a Message with Integrity information is sent. The Integrity parameter (identified by the security binding) is calculated as a function of the message content and encrypted in the Sending Entity. Then, a Message with Integrity information is answered. The Integrity parameter (identified by the security binding) is encrypted in the Receiving Entity.

30 The integrity information can be included in a new standard parameter (e.g.,

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integrity information) into the encrypted information parameter as described above.

Although not shown, an entity procedure similar to that shown in FIG. 7 may be performed for transmission of integrity information.

According to exemplary embodiments, mechanisms for authentication,
5 encryption, integrity and key handling are provided for insuring secure communications. Operations from non-authenticated nodes can be restricted. Backward compatibility is maintained, and forward compatibility is assured. The transmission mechanism is independent of the key handling and ciphering method. The Overhead related to encryption/decryption is only added to security sensitive messages, parameters and notes.
10 Although described with reference to security management in a GSM system using CCITT No. 7 signalling and CAP and MAP protocols, it will be appreciated by those of ordinary skill in the art that this invention can be embodied in other specific forms without departing from its essential character. For example, the principle of security management described above may be applicable to other types of signalling protocols
15 and/or other types of communication systems. The embodiments described above should therefore be considered in all respects to be illustrative and not restrictive.

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WE CLAIM:

1. An apparatus for providing secure communication between entities in one or more communication networks, comprising:

5 means for determining whether security measures needed for the communication exist between the entities;

if such measures do not exist, means for establishing security measures; and

10 means for establishing communication between the entities when the security measures have been established.

2. The apparatus of claim 1, wherein the security measures comprise security bindings including information needed for the secure communication.

15 3. The apparatus of claim 1, wherein the means for determining includes means for determining a security level needed for the communication, and the means for establishing includes means for requesting the security level and means for establishing security measures in response to the requested security level and based on predetermined security requirements.

20

4. The apparatus of claim 1, wherein the means for establishing security measures establishes security between entities in one or more networks based on predetermined security requirements.

25 5. The apparatus of claim 1, whether means for establishing security measures establishes the requested security between the entities communicating by establishing security bindings between at least the communicating entities depending on the information to be transmitted and/or the network to which the entities belong.

30

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6. The apparatus of claim 2, wherein the security bindings include information identifying the security binding.

7. The apparatus of claim 1, wherein the security measures include 5 encryption.

8. The apparatus of claim 2, wherein the security bindings include encryption information.

10 9. The apparatus of claim 7, wherein encryption is specified at a parameter level.

10. The apparatus of claim 1, wherein the security measures include authentication.

15

11. The apparatus of claim 2, wherein the security bindings include authentication information.

12. The apparatus of claim 10, wherein authentication is specified at a 20 parameter level.

13. The apparatus of claim 1, wherein the security measures include integrity.

14. The apparatus of claim 2, wherein the security bindings include integrity 25 information.

15. The apparatus of claim 13, wherein integrity is specified at a parameter level.

30 16. The apparatus of claim 2, wherein the security bindings include a list of

addressees or group of addressees included in the security bindings.

17. The apparatus of claim 1, wherein the means for determining determines whether the lifetime of the security measures has expired.

5

18. The apparatus of claim 2, wherein the security bindings include information regarding the lifetime of the security bindings.

19. The apparatus of claim 3, wherein the determining means determines whether the communication is between entities in the same network or between entities in different networks and requests a security level based on this determination.

20. A method for secure communication between entities in one or more communication networks, comprising the steps of:

15 determining whether security measures needed for the communication exist between the entities;

if such measures do not exist, establishing the security measures; and establishing communication when the security measures are established.

20 21. The method of claim 20, wherein the step of establishing the security measures includes establishing security bindings between the entities.

22. The method of claim 20, wherein the step of determining includes determining a security level needed for communication, and the step of establishing 25 includes requesting the security level and establishing security measures in response to the requested security level and based on predetermined security requirements.

23. The method of claim 20, wherein the step of establishing security measures includes establishing security measures between entities in one or more network 30 based on predetermined requirements.

24. The method of claim 20, whether the step of establishing security measures includes establishing the security measures between the entities communicating by establishing security bindings between at least the communicating entities depending on the information to be transmitted and/or the network to which the entities belong.

5

25. The method of claim 21, wherein the security bindings include information identifying the security binding.

10 26. The method of claim 20, wherein the security measures include encryption.

27. The method of claim 21, wherein the security bindings include encryption information.

15 28. The method of claim 26, wherein encryption is specified at a parameter level.

29. The method of claim 20, wherein the security measures include authentication.

20

30. The method of claim 21, wherein the security bindings include authentication information.

25 31. The method of claim 29, wherein authentication is specified at a parameter level.

32. The method of claim 20, wherein the security measures include integrity.

30 33. The method of claim 21, wherein the security bindings include integrity

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information.

34. The method of claim 32, wherein integrity is specified at a parameter level.

5

35. The method of claim 21, wherein the security bindings include a list of addressees or group of addressees included in the security bindings.

36. The method of claim 20, wherein the step of determining determines 10 whether the lifetime of the security measures has expired.

37. The method of claim 21, wherein the security bindings include information regarding the lifetime of the security bindings.

15 38. The method of claim 22, wherein the step of determining determines whether the communication is between entities in the same network or between entities in different networks and requests a security level based on this determination.

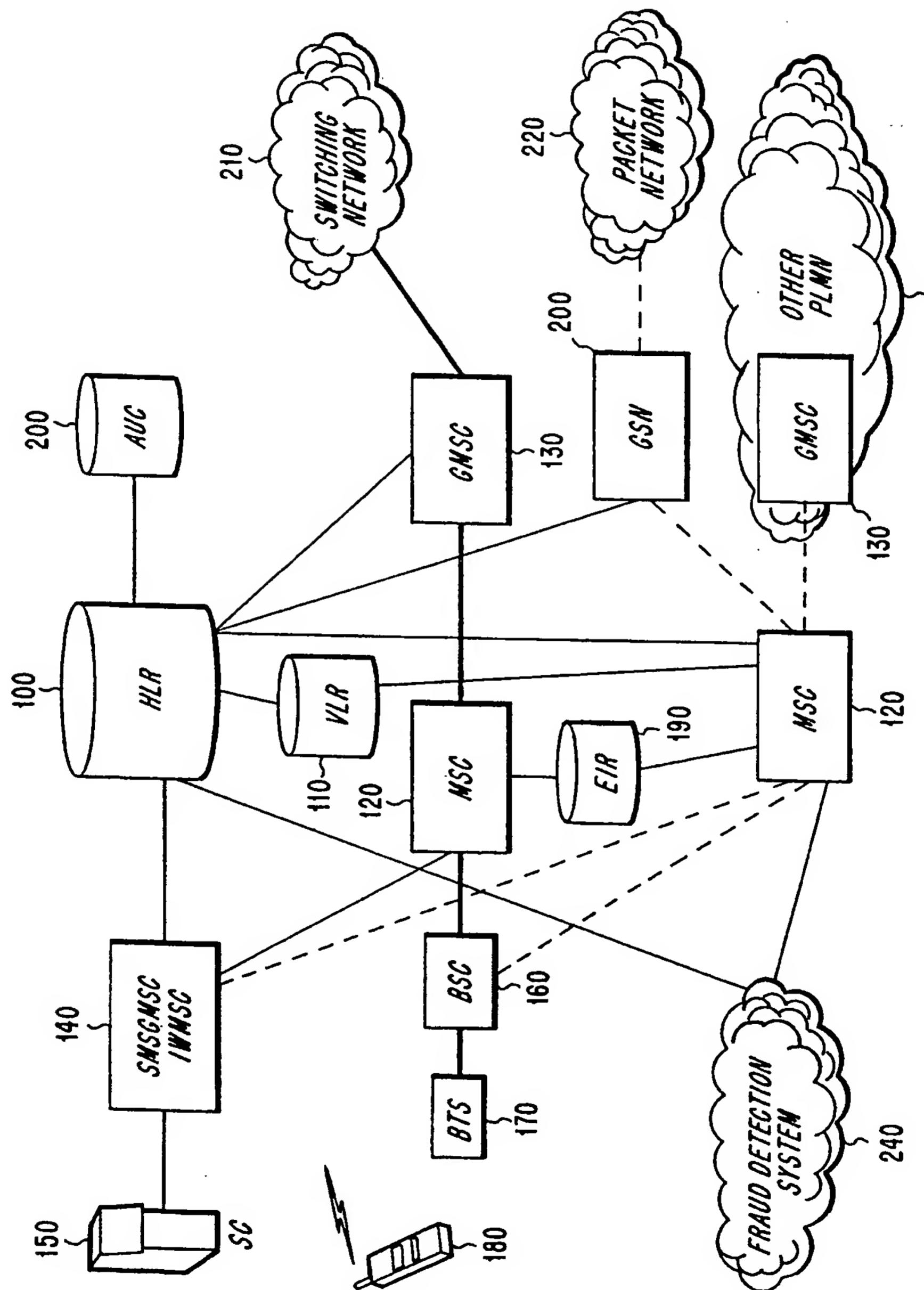


FIG. 1

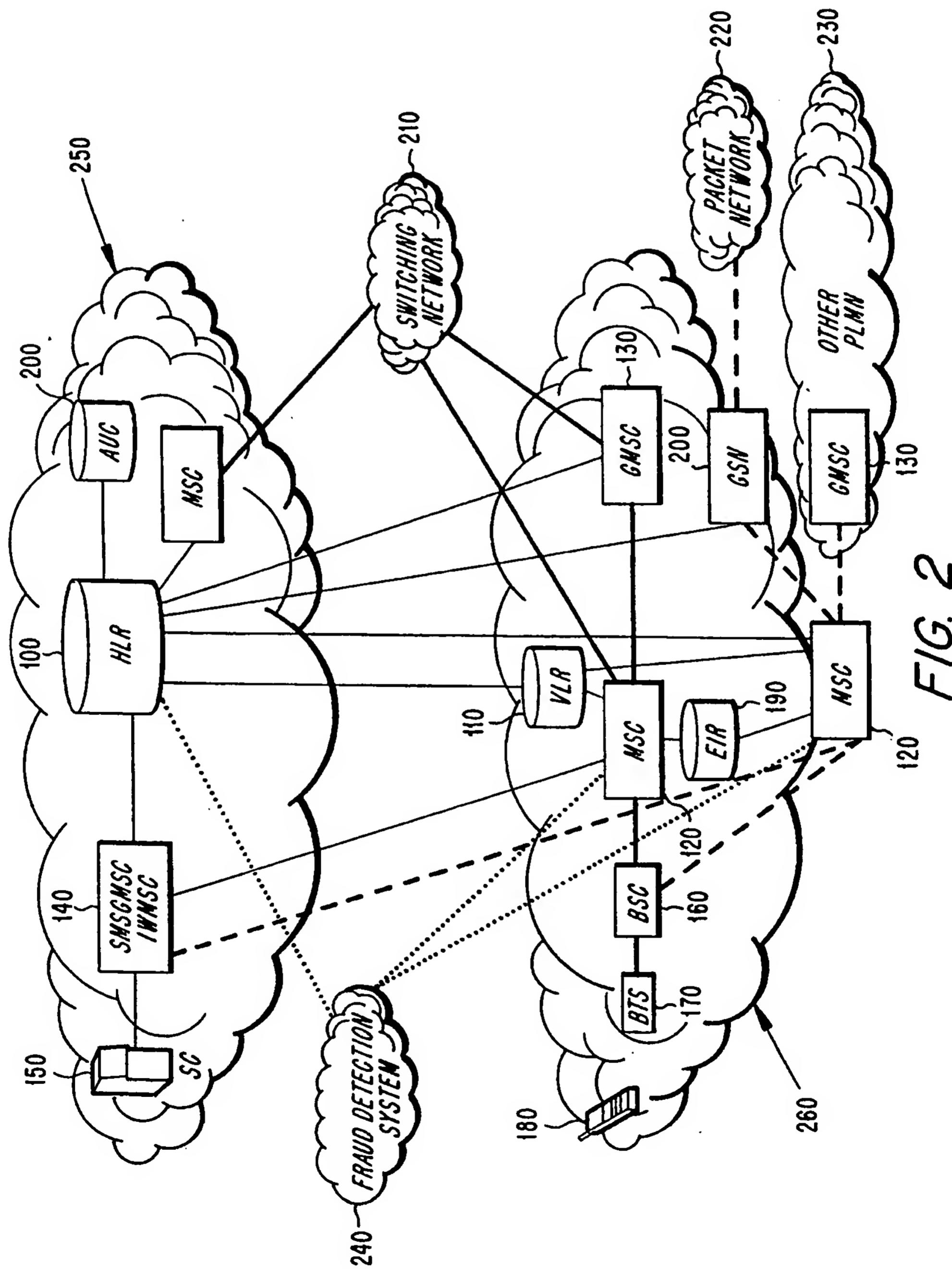


FIG. 2

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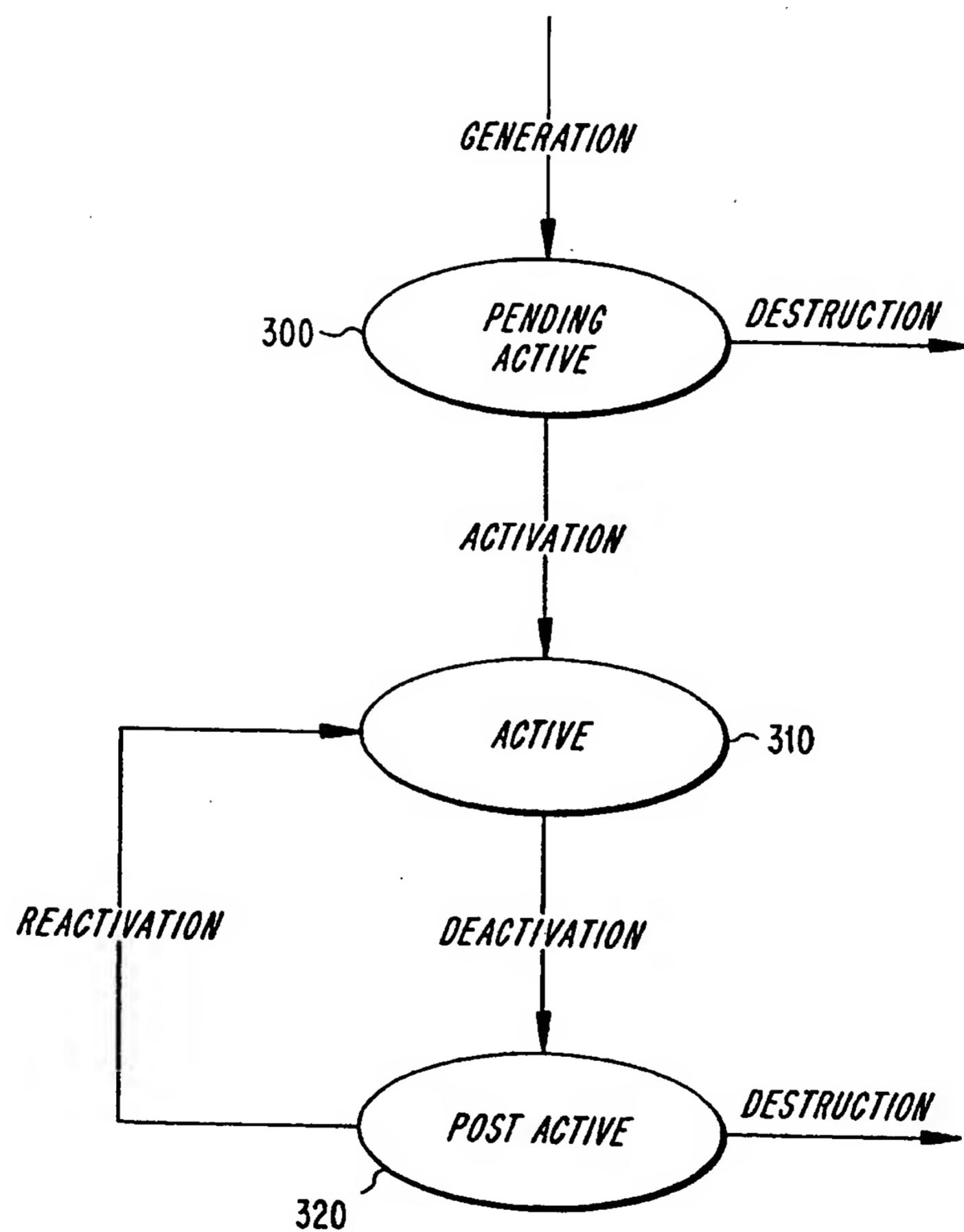
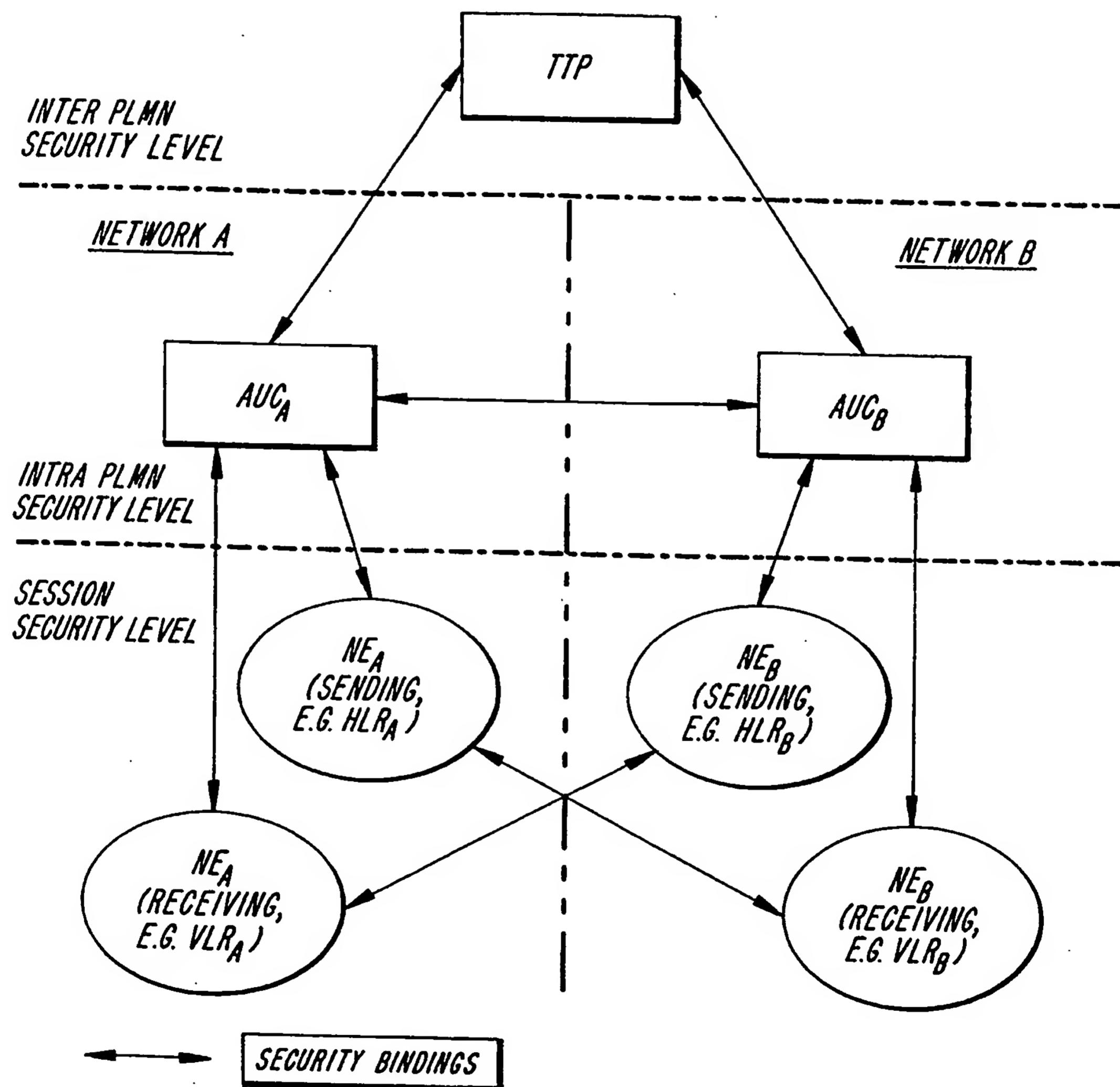


FIG. 3

FIG. 4



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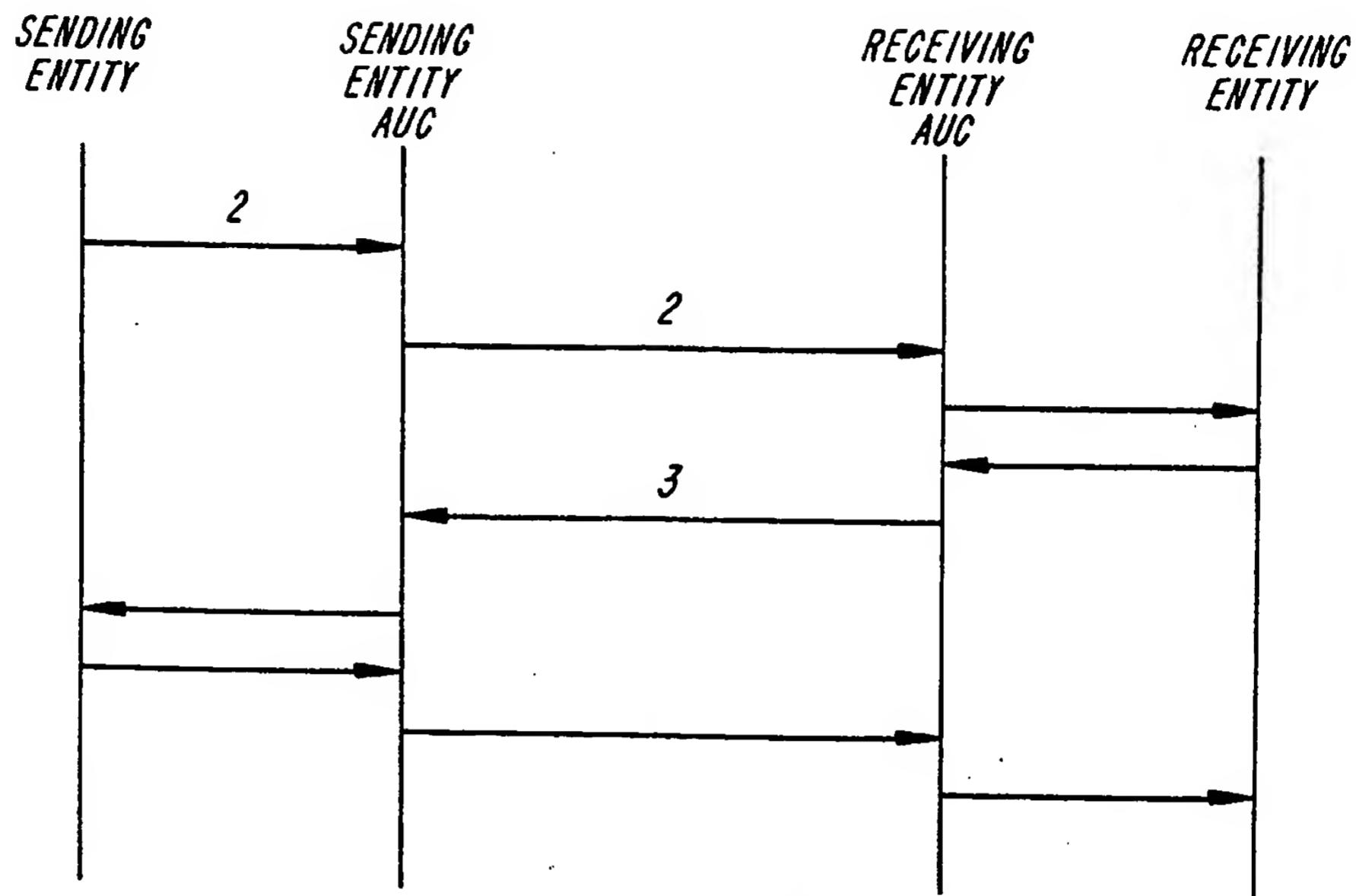


FIG. 5A

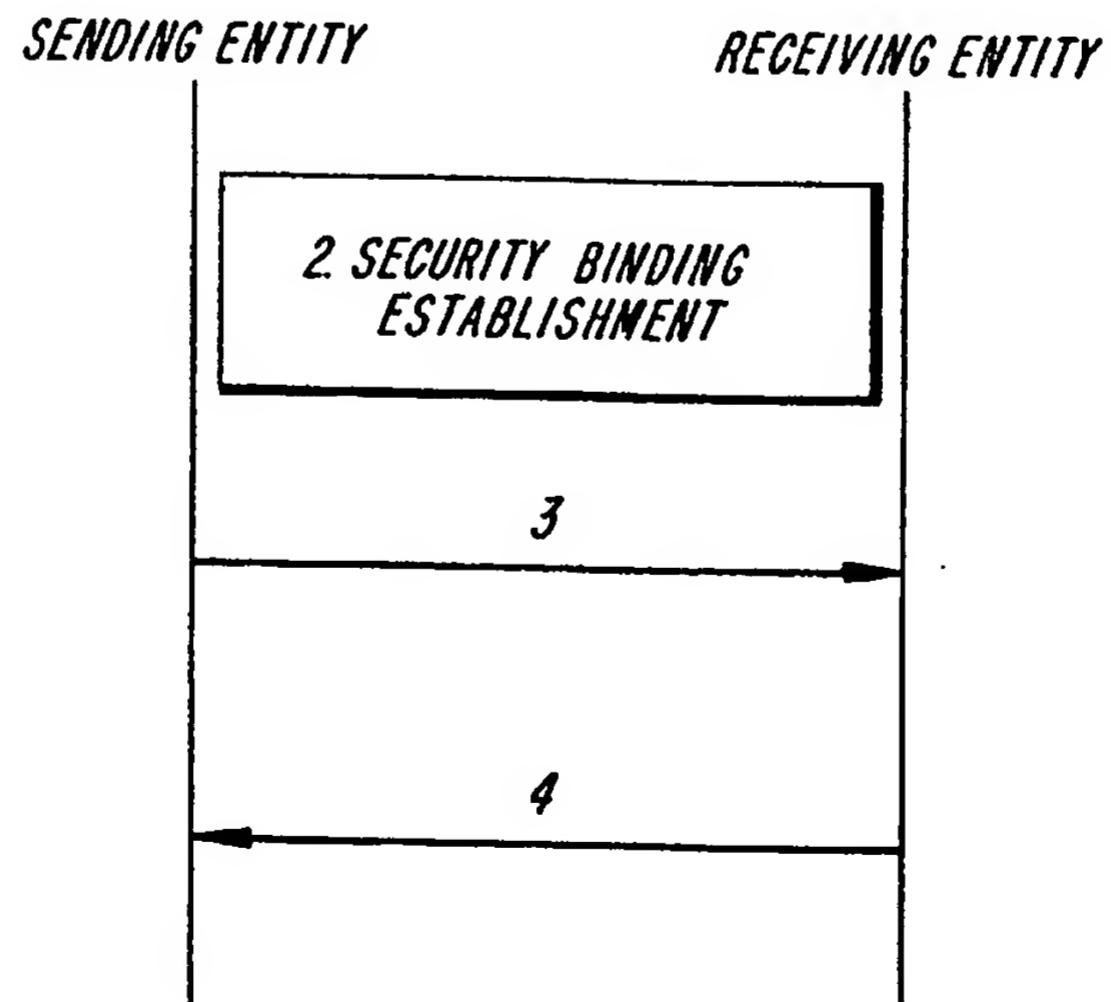
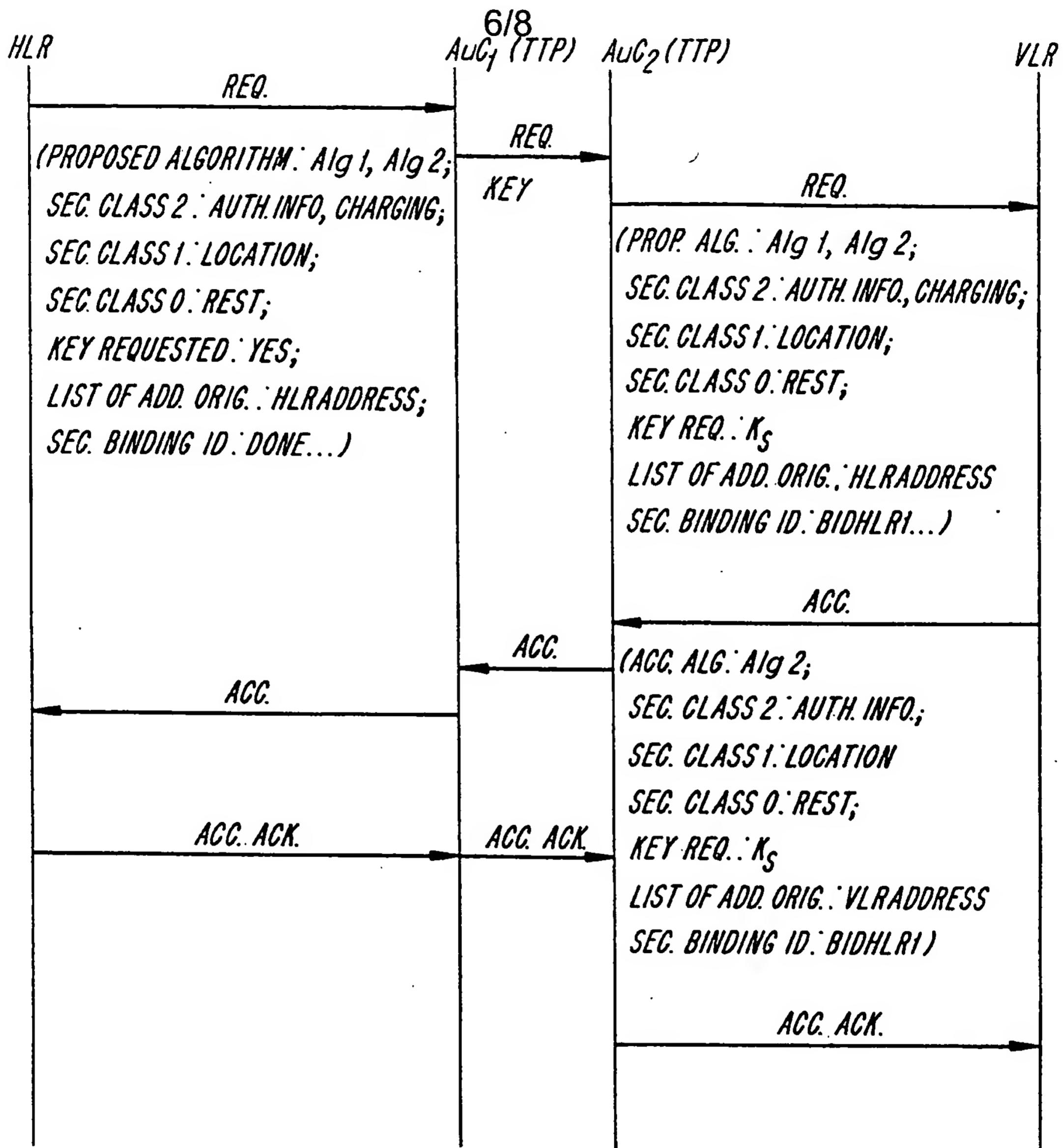


FIG. 6

INFO. STORED.:

BINDING: BIDHLR1
 ADDRESS: VLRADDRESS
 KEY: K_S
 PARAMS: AUTH. INFO.: CLASS 2
 LOCATION : CLASS 1
 ALGORITHM: Alg 2

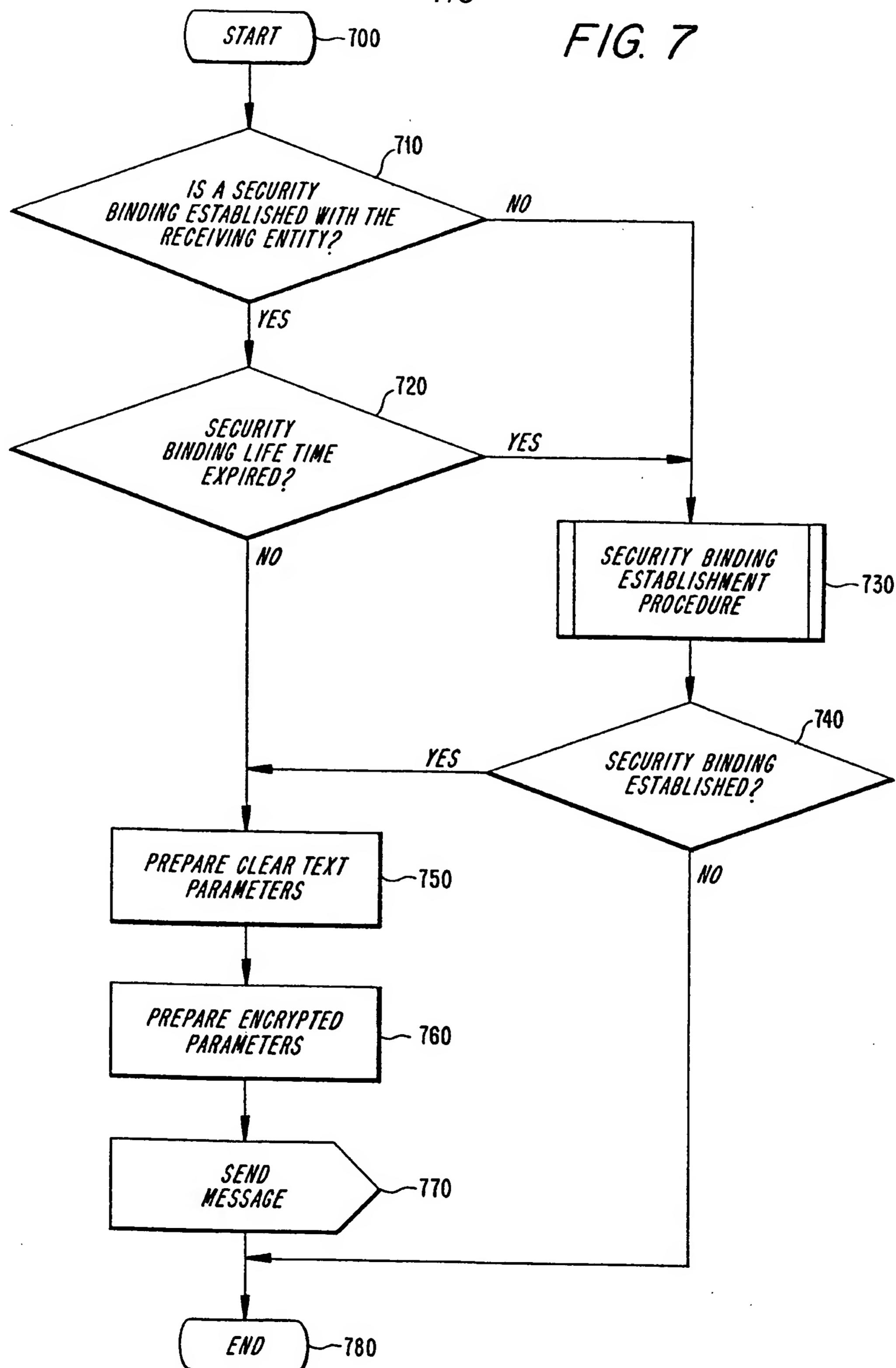
INFO. STORED.:

BINDING: BIDHLR1
 ADDRESS: HLRADDRESS
 KEY: K_S
 PARAMS: AUTH. INFO.: CLASS 2
 LOCATION : CLASS 1
 ALGORITHM: Alg 2

FIG. 5B

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FIG. 7



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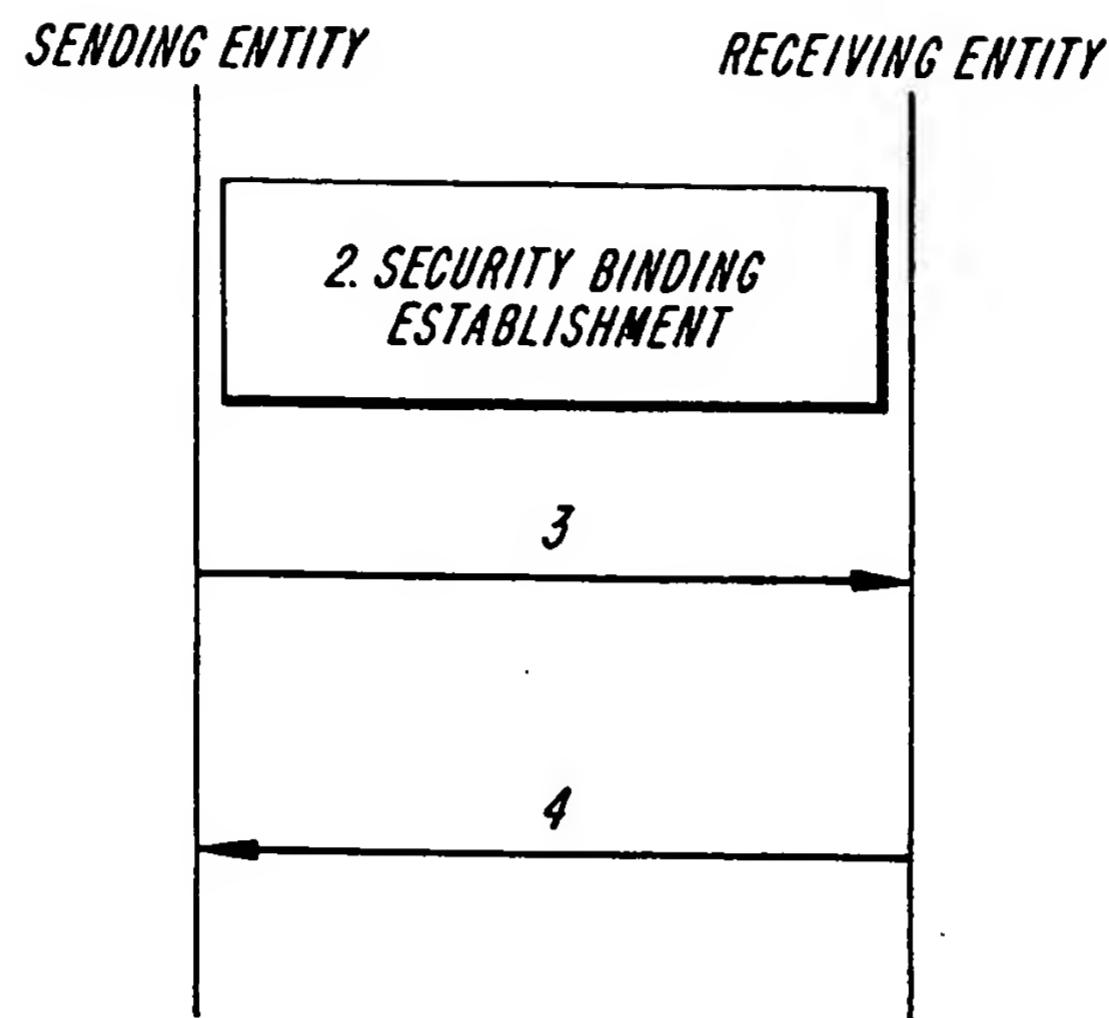


FIG. 8

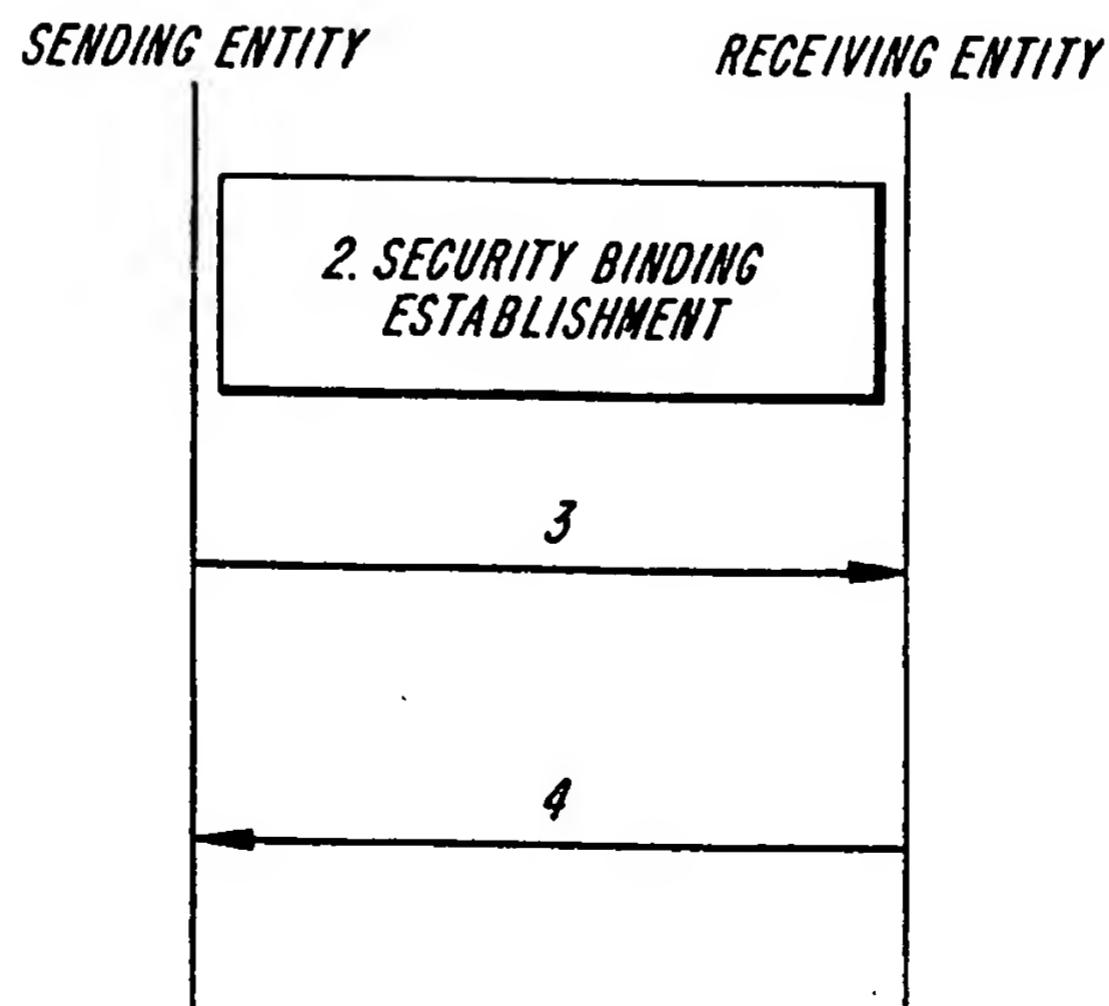


FIG. 9

INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/SE 00/01093

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category ¹	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 555 805 A (TALBOT ROBERT D) 26 November 1985 (1985-11-26) column 3, line 62 -column 4, line 31 ---	1,2,4,5, 7-9,20, 21,23, 24,26-28
X	US 4 920 567 A (MALEK CHARLES J) 24 April 1990 (1990-04-24) column 8, line 54 -column 9, line 48 ---	1,2,4,5, 7-9,20, 21,23, 24,26-28
A	GB 2 324 682 A (NIPPON ELECTRIC CO) 28 October 1998 (1998-10-28) page 3, line 14 -page 4, line 18 -----	1-38

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

¹ Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2000	28/09/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Weinmiller, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat'l Application No

PCT/SE 00/01093

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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